GLOBALEM 2022 - Laser generated EMP at LMJ-PETAL facility

EMP mitigation and equipment protection

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Abstract— Electromagnetic pulses (EMP) present a serious threat for operation of high-power, high-energy laser facilities. Here, we present the strategy implemented to manage these risks on the LMJ-PETAL large-scale facility that combines high-energy nanosecond laser beams and high-power picosecond beam. It is based on a dual approach: mitigation of the EMP emission and protecting the vulnerable devices. On one hand, the EMP emission is mitigated with a resistive and inductive target holder designed to reduce the current discharge. It has been tested and validated in experiments showing the efficiency of this device in the kJ/ps laser power range, with a reduction by a factor of 3 on the emitted EMP. On the other hand, the protection of the vulnerable equipment of the facility also rests on in the classical ElectroMagnetic Compatibility (EMC) technics: shielding of the devices, shielding and filtering of the cables. We present here the example of the innovative protection of the LMJ-PETAL VISAR (Velocity Interferometry System for Any Reflector) diagnostic, based on a Radiation-Absorbent Material (RAM) that was designed by simulation and qualification experiments.

Key words: EMP, Laser, EMC, mitigation, protection

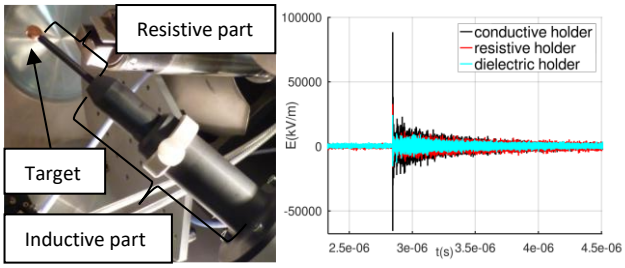

Figure 1. a) The mitigation device under test at CEA, DIF, Equinox facility. b) Time domain measurement of the EMP at CEA, CESTA, LMJ-PETAL facility.

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I. INTRODUCTION

The LMJ-PETAL nanosecond laser beams (300 kJ/3 ns in 2022) and picosecond beam (400 J/0.6 ps in 2022) are able to generate MV/m EMP in the GHz range inside the interaction chamber. This giant EMP may produce equipment failures and damages, and spurious signals in diagnostics. A dual approach, based on mitigation of the EMP emission and protection of the equipment, keeps the facility safe face to this threat and prepares it to the future energy upgrade of the LMJ and PETAL beams.

II. MITIGATION DEVICE

A. Main idea of the mitigation strategy

The main mechanism of the EMP generation is the induction of a discharge current through the target holder by the charge ejection from the laser-target interaction [1]. Our new resistive and inductive target holder (fig. 1a) reduces this return current, leading to a mitigation of the emitted EMP [2].

B. Recent developments on the mitigation device

A new resistive material (compound of polymer matrix and carbon nanotubes, made by mixing and injection molding) has been developed to play the role of the resistive part of the mitigation device. It has been successfully tested on several LMJ-PETAL shots in 2022 (fig. 1b).

III. EQUIPMENT PROTECTION

A. Key principles of the device protection

The susceptibility threshold of the most critical electrical devices of the facility has been deduced from experimental studies conducted with a high field pulsed generator. In order to keep the EM constraint under these thresholds, the vulnerable devices are set in Fadaray cages and cables are shielded or filtered.

B. Example of the VISAR diagnostic protection

The analysis table of the VISAR needs to be closed to the interaction chamber and bound to it through a metallic tubing for laser safety. A RAM has been added in the tubing and successfully mitigates the pulse propagation to the diagnostic shielded room.

REFERENCES

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[2] M. Bardon *et al.*, Phys. Rev. Res. 2, 033502 (2020)